

## IMPROVEMENT OF WHEAT PROTEIN BY SUPPLEMENTATION WITH POTATO FLOUR

M. Akmal Khan, Saeeda Jafri, Iftikhar A. Rana and Ihsan Ullah\*

**ABSTRACT:** The supplementary effect of boiled potato on the protein quality of wheat at 10% dietary protein level in weanling rats was studied. In the supplemented diet wheat supplied 75%, 50% and 25% protein while the rest was supplied by potato protein. The true protein digestibility (TD), net protein utilization (NPU), biological value (BV) and net dietary protein calorie percent (NDpCal%) of supplemented diets varied from 84 to 85%, 53 to 63%, 64 to 74% and 6.1 to 6.9%, respectively. Highest protein quality was obtained when 50% of protein of the diet was derived from each of the component. This mixture had 74% BV and was 30% higher than wheat (57%) and 18% higher than potato (63%) when each fed alone. TD of wheat protein was lowered by supplementation. NDpCal% values indicate that supplemented diets can meet the protein requirement of children and adults.

*Key Words: Wheats; Flour; Potatoes; Protein; Supplementary Feeding; Protein Metabolism; Nutritive Value; Pakistan.*

### INTRODUCTION

Among the various problems emerging out as a consequence of rapid population explosion, the problem of food particularly of good quality protein is reaching critical proportion, affecting most adversely the health and vitality of the nation.

Cereals constitute main staple of the Pakistani diet. According to the micro-nutrient survey of Pakistan (Government of Pakistan, 1978), wheat contributes 84% of the total cereal intake and provides 51% and 60% of the total calories and protein consumed, respectively. Wheat protein lacks the balance of essential amino acids required for its complete biological utilization (Khan and Eggum, 1979). According to Khan (1987), the order of limiting amino acids in wheat

protein is lysine, threonine and valine. Mixed human diets, breakfast cereals and baby foods based on wheat are deficient in lysine (Khan and Eggum, 1978, 1979a, b). The protein quality was lowered in wheat varieties having higher content of protein (Khan and Eggum, 1979a, b, Khan et al., 1987). On the other hand, the protein content of potato is comparable, on a dry basis, with that of the cereals. The biological value of this protein, being rich in lysine, is high (Khan and Hamid, 1986) and equals to that of egg protein when fed as a sole source of protein to man (Kofranyi et al., 1970). Some work on the improvement of wheat protein by supplementing with milk, fish, legumes and leaf protein has been done (Khan and Kissana, 1985; Khan et al., 1976a, b; 1977 and 1979a, b, c). There is no information available on the supplementary effect of potato consumed in Pakistan, on the protein quality of wheat. In this paper the effect of different levels of boiled potatoes on the protein quality of wheat as measured in rat assay has been reported.

\* *Food Technology and Nutrition Laboratories, National Agricultural Research Centre, Islamabad.*

## MATERIALS AND METHODS

Wheat 'Pak-81' and potato 'Cardinal' were procured from Wheat Programme and Pak Swiss Potato Project, National Agricultural Research Centre, Islamabad, Wheat was ground to whole flour by using Cyclotec mill. The potatoes were boiled in open pan for 45 min, peeled, mashed, freeze dried and analyzed. The experimental diets (Table 1) were prepared by mixing wheat and potato flours with corn starch to calculate protein levels of 10%. The experimental diets were isocaloric and isonitrogenous and contained no added fat. A protein free diet consisting of corn starch 58%, potato starch 10%, glucose 17%, vitamin and mineral mix 5% and corn oil 10% was included to measure metabolic faecal nitrogen.

**Table 1. Composition of experimental diets fed to albino rats (%)**

Ingredient	Diets				
	A	B	C	D	E
Wheat flour	82.9	62.2	41.5	20.7	-
Potato flour	-	22.1	44.2	66.2	88.3
Corn starch	17.1	15.7	14.3	13.1	11.7
Total	100.0	100.0	100.0	100.0	100.0
<b>Protein Distribution (%)</b>					
Wheat	100	75	50	25	-
Potato (boiled)	-	25	50	75	100

The chemical composition of wheat and potato flour diets was determined according to standard method (AOAC, 1970). The caloric value was determined in Ballistic Bomb Calorimeter.

### Biological Evaluation

The experimental procedure has been described by Khan and Munira

(1978). Forty weanling albino rats, weighing between 50 and 60 g were grouped by randomised block design. Each group consisted of four rats (male and female) housed in a screen mesh bottomed cage, a sheet of filter paper was placed under each cage for the collection of faeces. The experimental diets were randomly assigned to these groups in such a way that each diet was fed ad-libitum to two groups of rats for ten days. Gains in body weight were recorded daily.

At the end of experiment the rats were killed with chloroform. Incisions were made into skull, thoracic and abdominal cavities and the carcasses of each group were dried to a constant weight at 105°C. Dried carcasses were weighed and ground in an electric grinder. The nitrogen content of diets, faeces, and carcasses of each group was determined by using kjeltec auto analyser. Net protein utilisation was estimated according to the method of Miller and Bender (1955). True digestibility (TD) and biological value (BV) were derived as under:

$$TD (\%) = \frac{\text{Nitrogen intake} - [\text{Faecal nitrogen} - \text{metabolic nitrogen}]}{\text{Nitrogen intake}} \times 100$$

$$BV \% = \frac{\text{Net protein utilisation}}{\text{True digestibility}}$$

Net dietary protein calorie percent (NDpCal%) of diets was calculated according to Miller and Payne (1961).

## RESULTS AND DISCUSSION

The average values for true protein digestibility, net protein utilization, biological value and net dietary protein calorie percent are discussed in following text.

### True Protein Digestibility

The true digestibility (TD) of wheat protein was highest (90%) and it decreased significantly ( $P = 0.04$ ) by supplementation with all levels of potato protein (Table 2). The TD of supplemented diets ranged from 84% to 85%. The average TD of boiled potato was 85%. The true protein digestibility of freeze dried boiled potato is 85% which is in agreement with the values (82.8-90.8) obtained by Eppendorfer et al. (1979). Similarly, a value of 80% for TD of boiled potato has been reported by Khan et al. (1980). The low TD of potato protein as compared to wheat, observed in the present study, may be attributed to the poor digestibility of potato starch. Dreher et al. (1984) noted that the inferiority of potato starch to cereal starch with respect to its effect on protein utilization. More information is required about the degree of potato protein digestibility, either alone or in mixed diets.

### Net Protein Utilisation

Net protein utilization (NPU) increased from 51% in wheat based diets to 55%, 63% and 53%, respectively, in diets supplemented with 25%, 50% and 75% potato protein (Table 2). The NPU of diet containing 100% protein from potato was 54%. The NPU of the diet containing 50% from potato was the

highest and this value was highly significantly different ( $P = 0.003$ ) when compared to that of the wheat flour. Such diet presumably supplies all the essential amino acids. The low NPU of diets containing 100% and 75% protein from wheat is possibly due to the fact that lysine is the main limiting amino acid in these diets. A significant positive correlation ( $r = 0.92$ ) between available lysine and NPU of proteins with lysine as limiting amino acid has been reported (Khan, 1982). Similarly methionine may become the limiting amino acid when 75% to 100% of dietary protein are provided by boiled potato resulting in low NPU of the diets. Khan et al. (1979b) showed a positive correlation ( $r = 0.97$ ) between BV and total sulphur containing amino acids.

### Biological Value

The biological value (BV) of wheat and potato protein was 57% and 63%, respectively. The BV of diets increased to 65%, 74% and 64% when wheat and potato protein were mixed in 75 : 25, 50 : 50 and 25 : 75, respectively (Table 2). The BV of all the composite mixture was significantly ( $P = 0.002$ ) different from that of wheat. The BV of the diet containing 50% protein from each component, presumably supplying all the essential amino acids, is 30% higher than the diet based on wheat and 18% higher than the diet

**Table 2. Supplementary effect of potato on the protein quality of wheat**

Variable	Wheat flour	Wheat flour potato	Wheat flour potato	Wheat flour potato	Potato
Protein distribution (%)	100	75:25	50:50	25:75	100
True protein digestibility (%)	90 ± 2.00	85 ± 1.00	85 ± 0.57	84 ± 2.64	85 ± 0.57
Net protein utilization (%)	51 ± 2.08	55 ± 1.26	63 ± 2.58	53 ± 2.69	54 ± 13.81
Biological value (%)	57 ± 1.20	65 ± 0.73	74 ± 3.01	64 ± 1.17	63 ± 15.71
Net dietary protein calorie(%)	6.1 ± 0.25	6.5 ± 0.14	6.9 ± 0.30	6.1 ± 0.31	6.5 ± 1.69

containing 100% protein from potato. The BV of potato (63%) in the present study is higher than that of wheat which confirms that potato protein has a better essential amino acids composition than wheat protein (WHO, 1985). The protein scores of six potato varieties analysed by Kaldy and Markakis (1972) varied from 60 to 78, on the basis of the sulfur-containing amino acids. Lopez de Romana et al. (1981) confirmed that potato protein had an adequate ratio of total essential amino acids to total amino acids and a balance among individual essential amino acid concentration to meet the needs of infant and small children.

The present results are in line with the findings of Roy et al. (1963) who demonstrated that potato can supplement cereal protein. It is evident from the present study that maximum protein value is obtained when 50% of the protein in diet is derived from wheat and 50% from boiled potato. These figures correspond to 42 g of wheat flour and 44 g of freeze dried boiled potato with a 1 : 1 ratio. Similar results in a mixture of wheat and lentil have been reported (Khan et al., 1979b).

#### Net Dietary Protein Calorie Percent

The net dietary protein calorie percent (NDpCal%) of diets based on wheat and potato was 6.1 and 6.5, respectively. The NDpCal% of diets supplemented with different levels of potato ranged between 6.1 and 6.9, however, the NDpCal of the wheat and potato composite (50 : 50) was significantly ( $P = 0.025$ ) different from that of wheat flour.

According to FAO (1965), the protein allowances for different age groups in terms of NDpCal% are 8.0, 7.8, 5.9, 8.4, 4.6 and 9.5 for infant, toddler, child (4-9

years), adolescents, adult and lactating mothers, respectively.

It is of interest that the protein value of breast milk, expressed in the same units is also in the region of 8%. All supplemented diets in the present study have NDpCal% between 6.1 and 6.9 and can meet the protein requirements of children (4-9 years) and adults only. Similar results in combinations of boiled rice and cooked lentil and wheat and cooked lentils have been reported (Khan and Eggum, 1978; Khan et al., 1979a, b, c). The present findings agree well with work done in human nitrogen balance experiments with potato. Lopez de Romana et al. (1980) demonstrated that potatoes can meet the daily requirement for protein and a substantial part of that for energy of young children recovering from malnutrition. Similarly human adults were maintained in nitrogen equilibrium and good health on diets in which all the nitrogen was supplied by potatoes (Knorr, 1978).

In conclusion, potatoes are useful source of protein, especially if large amounts are eaten. In combinations with other foods, potato can supplement diets which are limiting in lysine. In Pakistan, potatoes are rarely consumed as the sole source of nitrogen in the diets of either adults or children, but they are commonly consumed either alone as potato chips, french fries etc. or in meat based or vegetable based dishes, with wheat *chapati* or boiled rice. Potatoes either in freshly boiled state or after processing and mixed with other foods or made denser calorically through the addition of oils should be encouraged as weaning food for infants. In search for higher yielding varieties, maintenance of protein level in potatoes should not be

overlooked by plant breeders. The processing and keeping quality should be improved by increasing the total solid contents and reducing the level of tyrosinase enzyme, responsible for the blackening of potato during storage and before or after cooking without affecting the normal nutritional composition or texture of the potato. There is also a need to encourage the production of potatoes to ease the pressure on wheat consumption in the country.

#### LITERATURE CITED

1. Association of Official Analytical Chemists (AOAC) 1970. Official Methods of Analysis. Washington D.C. 10th edn.
2. Dreher, M.L., Dreher, C.J. and Berry, J.W. 1984. Starch digestibility of foods: A nutritional perspective. *CRC Crit. Rev. Food Sci. Nutr.* 20 : 47-51.
3. Eppendorfer, W.H., Eggum, B.O. and Bills, S.W. 1979. Nutritive value of potato crude protein as influenced by manuring and amino acid composition. *J. Sci. Food Agric.* 30 : 361-368.
4. FAO, 1965. Committee on protein requirements. Nutritional studies. No. 37. Rome, Italy.
5. Government of Pakistan, 1978. Micronutrient Survey of Pakistan, Nutritional Cell, Planning Division, Islamabad.
6. Kaldy, M.S. and Markakis, P. 1972. Amino acid composition of selected potato varieties. *J. Food Sci.* 37 : 375-377.
7. Khan, M.A. 1981. Nutritional value of cereals in relation to human need. *Pakistan J. Agric. Res.* 2:141-146.
8. Khan, M.A. 1982. Available lysine as an index of dietary protein quality. *Pakistan Vet. J.* 2 : 167-168.
9. Khan, M.A. and Eggum, B.O. 1978. The nutritive value of Pakistani diets. *J. Sci. Food Agric.* 29 : 1023-1029.
10. Khan, M.A. and Eggum, B.O. 1979a. The nutritional quality of some Pakistani wheat varieties. *J. Sci. Food Agric.* 30 : 779-784.
11. Khan, M.A. and Eggum, B.O. 1979b. Effect of home and industrial processing on the protein quality of baby foods and breakfast cereals. *J. Sci. Food Agric.* 30 : 369-376.
12. Khan, M.A. and Hamid, T. 1986. Role of vegetables in human diet. *Progressive Farming*, 6: 10-14.
13. Khan, M.A. and Kissana, A.S. 1985. Nutritional evaluation of some commercial baby foods consumed in Pakistan. *J. Sci. Food Agric.* 36 : 1217-1274.
14. Khan, M.A., Rana, I.A. and Ullah, I. 1987. Nutritional evaluation of some commercial wheat varieties grown in Pakistan. *Plant Food Hum. Nutr.* 37 : 253-260.
15. Khan, M.A. and Munira, B. 1978. Biological utilization of protein as influenced by dietary carbohydrates. *Acta. Agric. Scand.* 28 : 282-284.
16. Khan, M.A., Almas, K., Abid, A.R. and Yaqoob, M. 1976a. The effect of gram flour on the quality of wheat protein Pakistan *J. Agric. Sci.* 13 : 167-172.
17. Khan, A.D., Abid, A.R. and Khan, M.A. 1976b. Supplementation of wheat flour with leaf protein concentrate (LPC). *The Nucleus*, 13 : 43-46.

18. Khan, M.A., Haq, R., Abid, A.R. and Yaqoob, M. 1977. The nutritive value of wheat flour (Mexi-Pak) as affected by supplementation with defatted soy flour. *Pakistan J. Agric. Sci.* 14 : 69-75.
19. Khan, M.A., Ahmed, J. and Abid, A.R. 1979a. Nutritive value of wheat flour as supplemented by lentils and fish meal. *J. Anim. Sci. (Pakistan)*. 1 : 51-56.
20. Khan, M.A., Yasmin, S.F. and Abid, A.R. 1979b. Nutritional evaluation of lentil as protein supplement for wheat protein. *Acta Agric. Scand.* 29: 109-111.
21. Khan, M.A., Jacobsen, I. and Eggum, B.O. 1979c. Nutritive value of some improved varieties of legumes. *J. Sci. Food Agric.* 30 : 395-400.
22. Khan, M.A., Almas, K. and Chaudhry, H.M. 1980. Predicting dietary protein quality by an in vitro method. *J. Anim. Sci. (Pakistan)*. 11 : 43-48.
23. Knorr, D. 1978. Protein quality of the potato and potato protein concentrates. *Lebensm. Wiss. Technol.* 11 : 109-115.
24. Kofranyi, E., Jekat, F. and Muller, W.A. 1970. The determinations of biological value of dietary proteins. XVI. The minimum protein requirement of humans, tested with mixture of whole egg plus potato and maize plus beans. *Hoppe-Seyler's Z. Physical. Chemie.* 351 : 1485-1493.
25. Lopez de Romana, G., Maclean, W.C., Placko, R.P. and Graham, G.G. 1981. Fasting and postprandial plasma free amino acids of infants and children consuming exclusively potato protein. *J. Nutr.* b, 111 : 1766-1771.
26. Lopez de Romana, G., David, G.G., Millit, E. and Maclean, W.C. 1980. Utilization of protein and energy of the white potato by human infants, *J. Nutr.* 110 : 1849-1857.
27. Miller, D.S. and Bender, A.E. 1955. The determination of the net utilization of proteins by a shortened methods. *Br. J. Nutr.* 9 : 382-388.
28. Miller, D.S. and Payne, P.R. 1961. Problems in the prediction of protein value of diets. The use of food composition tables. *J. Nutr.* 74 : 413-420.
29. Roy, R.N., Joseph, A.A., Sreenivas, H., Jayraj, A., Indiramma, K., Naryana, R.M., Sreenivas, A. and Subrahmanyam, V. 1963. Nutritive value of poor Indian diets based on potato. *Food Sci. (Mysore)* 12 : 258-262.
30. WHO, 1985. Energy and protein requirements. Report of joint FAO/WHO/UNU Expert Consultation, WHO Tech. Rep. Ser. 724, WHO, Geneva.